

CLAIMS

We claim:

- 5 1. An apparatus for programming, comprising:
 a non-volatile storage element having a gate and two control terminals; and
 a switchable current sinking device in communication with one of said control
terminals, said switchable current sinking device provides a coarse current sink to said
one of said control terminals if said non-volatile storage element is in a coarse
10 programming mode and provides a fine current sink to said one of said control terminals
if said non-volatile storage element is in a fine programming mode.
2. An apparatus according to claim 1, wherein:
 said coarse current sink is a greater current sink than said fine current sink.
- 15 3. An apparatus according to claim 1, wherein:
 said switchable current sinking device includes a single current sink that can
operate in two current sink modes.
- 20 4. An apparatus according to claim 1, further comprising:
 a sense circuit in communication with said non-volatile storage element; and
 a programming mode indication circuit providing an output indicating whether
said non-volatile storage element is in said coarse programming mode or said fine
programming mode based on said sense circuit, said switchable current sinking device is
25 in communication with said programming mode indication circuit and switches between
said coarse current sink and said fine current sink based on an output from said
programming mode indication circuit.

5. An apparatus according to claim 1, wherein:

said switchable current sinking device includes a first current sink unit that provides said coarse current sink, a second current sink unit that provides said fine
5 current sink, and a switch for selecting either said first current sink unit or said second current sink unit.

6. An apparatus according to claim 5, further comprising:

a sense circuit in communication with said non-volatile storage element; and
10 a programming mode indication circuit providing an output indicating whether said non-volatile storage element is in said coarse programming mode or said fine programming mode based on said sense circuit, said switch is in communication with said programming mode indication circuit and switches between said first current sink unit or said second current sink unit based on information from said programming mode
15 indication circuit.

7. An apparatus according to claim 1, further comprising:

a sense circuit in communication with said non-volatile storage element;
a programming mode indication circuit providing an output indicating whether
20 said non-volatile storage element is in said coarse programming mode or said fine programming mode based on said sense circuit, said switchable current sinking device is in communication with said programming mode indication circuit; and
a selection circuit in communication with said programming mode indication circuit and said sense circuit, said selection circuit provides a coarse reference signal to
25 said sense circuit if said non-volatile storage element is in said coarse programming mode and provides a fine verification signal to said sense circuit if said non-volatile storage element is in said fine programming mode.

8. An apparatus according to claim 7, wherein:

said sense circuit compares either said coarse reference signal or said fine reference signal to data for said non-volatile storage element based on output from said
5 program mode indication circuit to determine if said non-volatile storage element has reached a particular verification level.

9. An apparatus according to claim 8, wherein:

said programming mode indication circuit includes a storage unit, said storage
10 unit stores data indicating whether said non-volatile storage element is in said coarse programming mode or said fine programming mode.

10. An apparatus according to claim 7, wherein:

said sense circuit includes electronic circuitry to perform a bit line discharge
15 analysis to determine whether or not said non-volatile storage element meets a verification requirement.

11. An apparatus according to claim 1, wherein:

said two control terminals are bit lines.
20

12. An apparatus according to claim 1, wherein:

said one of said control terminals is a source terminal.

13. An apparatus according to claim 1, wherein:

said non-volatile storage element is a flash memory element.
25

14. An apparatus according to claim 1, wherein:

said non-volatile storage element is a multi-state flash memory element.

15. An apparatus according to claim 1, wherein:

said non-volatile storage element is a multi-state storage element; and

5 said switchable current sinking device provides different coarse current sinks to
said one of said control terminals for different states and provides different fine current
sinks to said one of said control terminals for different states.

16. An apparatus for programming a non-volatile storage element,
10 comprising:

a sense circuit in communication with said non-volatile storage element;

a programming mode indication circuit providing an output indicating whether
said non-volatile storage element is in a coarse programming mode or a fine
programming mode based on said sense circuit; and

15 a switchable current sinking device in communication with said programming
mode indication circuit and said non-volatile storage element, said switchable current
sinking device circuit provides a coarse current sink to said non-volatile storage element
if said non-volatile storage element is in said coarse programming mode and provides a
fine current sink to said non-volatile storage element if said non-volatile storage element
20 is in said fine programming mode.

17. An apparatus according to claim 16, wherein:

said coarse current sink is a greater current sink than said fine current sink.

25 18. An apparatus according to claim 15, wherein:

said switchable current sinking device includes a single current sink that can
operate in two current sink modes.

19. An apparatus according to claim 16, wherein:

said switchable current sinking device includes a first current sink unit that provides said coarse current sink, a second current sink unit that provides said fine
5 current sink, and a switch for selecting either said first current sink unit or said second current sink unit; and

said switch is in communication with said programming mode indication circuit and switches between said first current sink unit or said second current sink unit based on information from said programming mode indication circuit.

10

20. An apparatus according to claim 16, wherein:

said switchable current sinking device is in communication with a source terminal of said non-volatile storage element.

15

21. An apparatus according to claim 16, wherein:

said switchable current sinking device is in communication with a bit line of said non-volatile storage element.

22. An apparatus according to claim 16, wherein:

20

said switchable current sinking device is in communication with a control line of said non-volatile storage element.

23. An apparatus according to claim 16, wherein:

said non-volatile storage element is a flash memory element.

25

24. An apparatus according to claim 16, wherein:

said non-volatile storage element is a multi-state flash memory element.

25. An apparatus according to claim 16, wherein:

said switchable current sinking device provides different coarse current sinks for different states and provides different fine current for different states.

5

26. An apparatus for programming non-volatile storage elements, comprising:
a programming circuit in communication with said non-volatile storage elements;
and

one or more switchable current sink circuits in communication with said non-
10 volatile storage elements, said one or more current sink circuits cause a first subset of
said non-volatile storage elements in a coarse programming phase to be subjected to a
first current sink while concurrently a second subset of said non-volatile storage elements
in a fine programming phase are subjected to a second current sink.

15 27. An apparatus according to claim 26, wherein:

said programming circuit provides a common steering signal to said non-volatile
storage elements.

28. An apparatus according to claim 26, wherein for a particular non-volatile
20 storage element, one of said switchable current sink circuits comprise:

a sense circuit in communication with said particular non-volatile storage
element;

a programming mode indication circuit providing an output indicating whether
said particular non-volatile storage element is in said coarse programming phase or said
25 fine programming phase based on said sense circuit; and

a switchable current sinking device in communication with said programming
mode indication circuit and said particular non-volatile storage element, said switchable

current sinking device provides said first current sink to said particular non-volatile storage element if said particular non-volatile storage element is in said coarse programming phase and provides said second current sink to said particular non-volatile storage element if said particular non-volatile storage element is in said fine programming phase.

29. An apparatus according to claim 28, wherein:
said first current sink is a greater current sink than said second current sink.

30. An apparatus according to claim 28, wherein:
said switchable current sinking device includes a single current sink that can operate in two current sink modes.

31. An apparatus according to claim 28, wherein:
said non-volatile storage elements are flash memory elements.

32. An apparatus according to claim 28, wherein:
said non-volatile storage elements are multi-state flash memory elements.

33. An apparatus for programming, comprising:
means for performing coarse programming phase for non-volatile storage elements;
means for sinking a first current during said coarse programming phase; and
means for switching to fine programming for said non-volatile storage elements
by switching said sinking to a second current.

34. An apparatus according to claim 26, wherein:

said one or more switchable current sink circuits includes one switchable current sink circuit per non-volatile storage element.

35. A method for programming, comprising:
5 performing a coarse programming phase for a non-volatile storage element, said coarse programming phase includes sinking a first current; and
switching to a fine programming phase for said non-volatile storage element by switching said sinking to a second current.

10 36. A method according to claim 35, further comprising:
determining whether a threshold voltage of said non-volatile storage element has reached a first verify level, said step of switching is commenced when said threshold voltage of said non-volatile storage element has reached said first verify level; and
determining whether said threshold voltage of said non-volatile storage element
15 has reached a second verify level, said fine programming phase is completed when said threshold voltage of said non-volatile storage element has reached said second verify level.

37. A method according to claim 35, wherein:
20 said first current is greater than said second current.

38. A method according to claim 35, wherein:
said non-volatile storage element is a flash memory element.

25 39. A method according to claim 35, wherein:
said non-volatile storage element is a multi-state flash memory element.

40. A method according to claim 35, wherein:
change in a threshold voltage of said non-volatile storage element is decreased
during said fine programming phase in comparison to said coarse programming phase

5 41. A method for programming, comprising:
applying a program voltage signal to a non-volatile storage element;
sinking a first current from said non-volatile storage element to perform coarse
programming;
determining that a threshold voltage of said non-volatile storage element has
10 reached a first verify level;
switching said sinking to sink a second current in response to determining that
said threshold voltage of said non-volatile storage element has reached said first verify
level, said step of switching causes said non-volatile storage element to perform fine
programming.

15 42. A method according to claim 41, wherein:
said first current is greater than said second current.

43. A method according to claim 41, wherein:
20 said non-volatile storage element is a flash memory element.

44. A method according to claim 41, wherein:
said non-volatile storage element is a multi-state flash memory element.

25 45. A method according to claim 41, wherein:
said program voltage is applied to a control gate of said non-volatile storage
element.

46. A method for programming, comprising:

performing a coarse programming phase for multi-state non-volatile storage elements, said coarse programming phase includes sinking a first set of currents such that
5 non-volatile storage elements being programmed to different states sink different currents of said first set of currents; and

switching to a fine programming phase for said non-volatile storage elements by switching said sinking to a second set of current such that non-volatile storage elements being programmed to different states sink different currents of said second set of currents.

10